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(54) IMPROVEMENTS IN FLUORESCENT LAMPS

(71) We, General Electric Company, a corporation organized and existing under the laws of the State of New York, United States of America, of 1 River Road, Schenectady 12305, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to fluorescent lamps which are adapted as direct replacements for existing incandescent lamps. More specifically, this invention concerns fluorescent lamps wherein ionization is induced by a transformer which is partially contained within the lamp envelope.

The incandescent lamp is the primary luminary for household and residential lighting. This lamp generally includes an incandescent filament within a predetermined non-oxidizing atmosphere which is contained within a teardrop shaped envelope and mounted, for example, within an Edison type base which is screwed into a permanent fixture or into a movable socket.

Despite their widespread use, incandescent lamps are relatively inefficient, producing only 15–17 lumens per watt of input power and have relatively short, unpredictable service lives. Fluorescent lamps, which have efficiencies as high as 80 lumens per watt, provide an attractive alternative to incandescent lighting. Conventional fluorescent lamps, however, require a long tubular envelope which, together with the need for auxiliary ballasting equipment, has somewhat limited their acceptance in the home lighting market. Increased residential use of fluorescent illumination, with attendant savings of energy, can be achieved from the development of fluorescent lamps which are directly compatible with existing sockets and incandescent lamp fixtures.

U.K. Patent Application No. 2226/76 (Serial No. 1,555,095), discloses fluorescent lamps which may be constructed within a spherical or teardrop shaped structure typical of residential incandescent lamps. A toroidal ferrite core contained within the lamp envelope is excited with a radio frequency magnetic field. The core induces an electric discharge in gas contained within the lamp. Radiation from this ionized gas excites a conventional lamp phosphor on the inner surface of the envelope and on the outer surface of the core to produce visible light.

The magnetic core of the lamps disclosed in Application No. 2226/76 (Serial No. 1,555,095) is contained wholly within the lamp envelope. Despite the improved efficiency of those lamps, up to a quarter of the radio frequency input power is dissipated within the core and winding structures. To provide for efficient operation, the operating temperature of ferrite cores and lamp phosphors are, generally, restricted to the region below 125°C. Thus, limited heat transfer from the transformer core is a major factor in determining the maximum light output available from those lamps. Structures disclosed in Patent Application No. 2226/76 (Serial No. 1,555,095) include metal rods for conducting heat through the lamp envelope so that it may be dissipated to the atmosphere.

The operation and efficiency of fluorescent lamps may be degraded if materials within the envelope act to contaminate the phosphors or to change the gas pressures. Many ferrite materials, which are otherwise suitable for use in these lamps, tend to outgas at lamp pressures and may evolve potentially damaging substances, for example oxygen and water vapour, into the envelope. In addition, these ferrite materials are generally unreceptive to the application of phosphor coatings. In accordance with the teachings of Patent Application No. 2226/76 (Serial No. 1,555,095) a thin glazing is applied to the ferrite lamp

components to improve the adherence of phosphors (which may then be applied using conventional/heating Lehring processes) and to contain gases which may evolve from the ferrite.

According to one aspect of the present invention there is provided a fluorescent lamp comprising:

a light-transmissive envelope having a substantially globular portion;

a closed loop core structure consisting of ferrite having a central opening, lying partially within and partially without said envelope;

means for energizing said core with a radio frequency magnetic field;

an ionizable medium within said envelope adapted to sustain an electric discharge due to an electric field induced therein by said ferrite core and to emit radiation at a first wavelength when sustaining said discharge; and

a luminescent phosphor disposed on the interior of said envelope and on the surfaces of said ferrite core structure lying within said envelope, said phosphor being adapted to emit visible light when excited by said first wavelength radiation.

According to another aspect of the present invention, there is provided a fluorescent lamp comprising:

a light-transmissive envelope having a substantially globular portion, a flat base part, and a re-entrant tubular projection containing two oppositely positioned rectangular perforations and extending from said base part;

a closed loop core structure consisting of ferrite having a central opening, sealably penetrating said envelope through said rectangular perforations;

means for energizing said core structure with a radio frequency magnetic field;

an ionizable medium, contained within said envelope, adapted to sustain an electric discharge due to an electric field induced therein by said ferrite core structure and to emit radiation at a first wavelength when sustaining said discharge; and

a luminescent phosphor disposed on the interior of said envelope and on the surfaces of said ferrite core structure lying within said envelope, said phosphor being adapted to emit visible light when excited by said first wavelength radiation.

Thus, there is provided a fluorescent lamp induction transformer structure wherein a portion of a closed ferrite core is mounted externally to a lamp vacuum envelope. Portions of these transformer core surfaces may be exposed to the atmosphere to provide improved cooling and heat transfer from the ferrite and winding structures. The transformer primary winding can be placed on an external core segment which allows the use of less expensive winding materials than are required in known lamps. In one embodiment of the present invention, the transformer core structure is enclosed in a metal container having a surface which is receptive to phosphor application. The glassy layer which is applied to the ferrite core structure in other lamps is thereby eliminated. The transformer core structure may be sealed to a lamp base using a single glass disk seal.

The present invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

FIGURE 1 is a front sectional view of a known induction ionized fluorescent lamp;

FIGURE 2 is a sectional side view of a lamp structure incorporating the present invention;

FIGURE 3 is a front sectional view of the lamp structure of FIGURE 2;

FIGURE 4 is a partial side view of another embodiment of a lamp structure incorporating the present invention.

FIGURE 5 is a front sectional view of the lamp structures of FIGURE 4.

FIGURE 6 is a view of the lamp structures of FIGURES 4 and 5;

FIGURE 7 depicts a method of production of the lamp structures of FIGURES 4, 5 and 6; and

FIGURE 8 depicts a complete lamp structure including a power supply and a screw base.

The principles of operation of electrodeless fluorescent lamps are described in United States Patents 3,500,118 and 3,521,120. The principles may best be understood by reference to FIGURE 1 which is a sectional view of a known electrodeless fluorescent lamp having an induction transformer core wholly contained within an ionizable gas. A light transmissive, evacuable, envelope 11, is mounted on a base assembly 14 which supports a lamp base plug 13. A radio frequency power supply 16 contained within the base assembly causes current flow through metal rods 15 and a primary winding 17 which excites a radio frequency magnetic field in a toroidal, ferrite, transformer core 12, which is contained within the light transmissive envelope 11.

The radio frequency power supply 16 may be of any type known to the art. For example, the inverter circuit which is described in United States Patent 3,521,120 would be suitable for use with lamps operating in its power range.

The space within the envelope contains an ionizable gas 19, which links the transformer core, i.e. constitutes a secondary winding of the core. The radio frequency magnetic field within the transformer core

12 induces an electric field which ionizes the gas 19. Upon transition to the ionized state, the gas emits radiation in the ultraviolet region. The internal surfaces of the envelope 11 and the external surfaces of the transformer core 12 are coated with an appropriate lamp phosphor 20, which phosphors are well known to the art. The phosphors are capable of absorbing ultraviolet radiation from the gas which is generally peaked at about 2537 Å and, upon stimulation thereby, emitting radiation within the visible spectrum to produce a highly efficient and pleasing light output. The ionized gas is thus not relied upon to produce the light emission, but rather, to produce radiation which causes light to be emitted from a luminescent phosphor. This allows for relatively low power input to the ionizable gas since the gas itself is not relied upon for the necessary light emission, but only for radiation to stimulate the phosphor.

The gaseous ionizing medium 19 in lamps of this type is typically a mixture of rare gas (for example krypton) and mercury vapour at a pressure between approximately 0·2 and approximately 2·0 torr. These are poor thermal conductors and are generally insufficient to transfer the heat produced by losses within the transformer core 12 and winding 17.

In accordance with one embodiment of the present invention, illustrated in FIGURE 2, structures are provided whereby a transformer core assembly lies partially within and partially without a fluorescent lamp envelope. As in prior art lamps, an evacuable, light transmissive envelope 11 (which may, for example, be glass) is filled with a gaseous ionizing medium 19. The lamp envelope has a flat base area 11a having a rectangular slot 26a in which is mounted a transformer core assembly 12 having a central winding space 30, which, as depicted in FIGURE 3, may comprise an annular ferrite core of rectangular cross-section 18 enclosed with an annular metal container 24. The core assembly 12 lies partially within and partially without the lamp envelope 11 so that a minor segment of the core assembly 12 and space 30 contained by it extend into the atmosphere beyond the lamp envelope base 11a. The interior of the lamp envelope 11 and the exterior surfaces of the metal container 24, which lie within the lamp envelope, are coated with a phosphor 20. That portion of the rectangular slot 26a lying within the core winding space 30 is covered and sealed with a rectangular glass bridge 26. A primary winding 17 is wrapped around the metal container 24 through the winding space segment 30. Current from a radio frequency power supply 16 flows through the winding 17, exciting the core with a magnetic field which acts to induce ionization of the gaseous medium and production of visible light output in the manner described above. A heat sink 28 is bonded to the metal container 24 at a point outside the lamp envelope 11. Heat transferred to the sink 28 is dissipated to the atmosphere or conducted to a suitable radiator on a lamp base (not shown). Details of the metal container 24 construction are shown in FIGURE 3. The container may be constructed from copper, beryllium, aluminum, or any other metal compatible with the low pressure lamp atmosphere and suitable for receipt of the fluorescent lamp phosphor 20. The container 24 forms a smooth unbroken shell around the major circumference of the ferrite core 18, but contains a gap extending around its inner major circumference which prevents short-circuiting of the induced electric field. Electrical insulation and vacuum integrity across this gap are maintained by a glass seal 27. The container 24 may be coated with a glassy layer 23 in order to improve adhesion of the phosphor 20.

Obviously, the choice of ferrite core material is an important factor in enabling operation of this lamp. Ferrite material is chosen to provide high permeability and low internal heat loss at the operating frequency. As is well known to the art, a ferrite is a ceramic-like material characterized by ferromagnetic properties and usually exhibits a spinel structure having a cubic crystal lattice and has the generalized formula Me-Fe_2O_4 wherein Me represents a metal atom.

The cores are preferably of material and configuration such that the core losses are not greater than 50 percent in order that effective coupling of electromagnetic energy into the light source may be effected. Similarly, low core losses reduce heating of the core and minimize the possibility of failure and maximize energy transfer efficiency. Preferably, core losses are maintained to less than 25 percent of total input power.

A high permeability core material is also desirable to assure adequate coupling of radio frequency energy to the gas with minimum electromagnetic radiation. A ferrite having a relative permeability of at least 2000 is preferable. Suitable ferrites are available having these characteristics over the frequency range from 25 kHz to MHz. Although high frequency operation is desirable from the standpoint of minimizing ferrite losses, the cost of presently available semiconductors for use in the radio frequency power supply 16 limits the maximum frequency at which a practical lamp may be operated to approximately 50 kHz.

Among other materials, ferrite type 8100, manufactured by the Indiana General Corp. of Keysbee, New Jersey, and characterised by losses of less than 30 mw cm^{-3} at 1000 gauss peak flux density for 50 kHz operation is suitable for use in this lamp.

In another embodiment of this invention, shown in FIGURES 4 to 8, a transformer core assembly is supported by a re-entrant tubulation 11b extending from the lamp base 11a. The core assembly 12 passes through a pair of rectangular slots 11c in the sides of the tubulation 11b and is secured thereto by glass seals 27a. A circular cover 29 closes the top of the rectangular slots and is sealed to the tubulation 11 b and the internal surface of the transformer core assembly 12.

The core assembly 12 in this embodiment may comprise a ferrite core 18 which may be wrapped about its outer circumference with a metal strap 25 which supports the core and aids in the removal of heat generated therein. Those portions of the strap 25 and the core 18 lying within the lamp envelope 11 may, for example, be coated with a glassy layer 23 to facilitate the receipt of the phosphor 20 and sealing to the cover 29 and the base tubulation 11b. As in the above described embodiment, a transformer primary winding 17 is wrapped about the ferrite core and metal strap and is enclosed inside that portion of the core winding space 30 which is within the tubulation 11b but which is exposed to the external atmosphere. A metal heat sink 28 is bonded to the strap 25 inside the tubulation 11b and serves to conduct heat away from the core assembly 12.

Further details of the lamp construction are shown in FIGURE 7 which depicts the lamp base 11a with the re-entrant tubulation 11b and rectangular slots 11c. The disk-shaped glass cover 29 is indicated prior to mounting on the tubulation 11b.

The lamp may, by way of example, be constructed by first preforming a glass lamp base 11a with a re-entrant tubulation 11b and rectangular slots 11c. A glass coated transformer core assembly 12 with a winding 17 attached is inserted in slots 11c and covered by a glass disk 29. Upon heating, the glass tubulation 11b fuses with the core coating layer and glass disk 29 to provide the vacuum seals (27a of FIGURES 3 and 4). The envelope upper shell (not shown) is then sealed to the base, exhausted, and filled with gas in a conventional manner. Alternatively, the transformer winding 17 may be applied to the core assembly 12 after the sealing process is complete.

Obviously, the construction of glass-to-ferrite seals is necessary for the practice of this invention. These seals may be constructed if, as is well known in the art, the thermal expansion coefficient of the sealing glass is matched to that of the ferrite. Applicable ferrites have linear expansion coefficients of approximately 11 ppm/°C. at 400°C. and exhibit a linear expansion which is proportional to temperature change up to 700°C. Many glass types are available having coefficients of expansion in this range. For example, Corning (Registered Trade Mark) Glass Type No. 1190, which is a potash soda lead type, has a coefficient of expansion of 12·4 ppm/°C. and is suitable for ferrite sealing. Glass No. 1190 is commonly used for sealing to iron and is also suitable for sealing to beryllium which has an expansion coefficient of 11·6 ppm/°C.

FIGURE 8 depicts a complete lamp assembly incorporating the principles of this invention. A lamp base plug 13, which may, for example, be an Edison screw base, is mounted to one end of a cylindrical base assembly 14. The base assembly 14 contains a suitable radio frequency power supply and ballast circuit 16. The radio frequency power supply receives input power line energy from the base plug 13 and transforms it to radio frequency current which is applied to a ferrite transformer core assembly 12 through a primary winding 17. A light transmissive, evacuable envelope 11 is coated with a phosphor 20 and is mounted to an end of the base assembly 14 opposite the plug 13. The base of the envelope 11a is enclosed by the base assembly 14 and supports a re-entrant circular tubulation 11b through which the toroidal ferrite transformer assembly 12 is mounted. A circular glass disk 29 covers the innermost end of the tubulation 11b. A gas filling 19, which may for example be a mixture of mercury vapour and krypton, fills the envelope and links the transformer core assembly 12. The primary winding 17 links the transformer core assembly 12 with a plurality of turns and lies within the envelope tubulation 11b. A heat sink 28 is bonded to the transformer core assembly 12 within the tubulation 11b and serves to conduct away heat. The space within the tubulation 11b and the base assembly 14 may, if desired, be filled with a thermally-conductive resinous material (not shown) to further improve heat transfer from the core assembly.

From the above description of the preferred embodiments, it may be seen that a structure affording greatly improved heat transfer characteristics from the windings and core of an electrodeless fluorescent lamp is provided. The transformer core of this lamp is partially contained within the lamp envelope which allows construction of a lamp with highly efficient electrical coupling between a gaseous ionizing

medium and the remainder of the transformer and with a shape compatible with residential incandescent lamps and luminaires. Further, the transformer core lies partially outside of the lamp envelope, eliminating the need for the electrical, vacuum feedthroughs characteristic of other lamps while affording increased heat transfer from the core and winding assemblies. The transformer core may be easily mounted to a lamp envelope base using simple, glass preform structures.

WHAT WE CLAIM IS:—

1. A fluorescent lamp comprising:

a light-transmissive envelope having a substantially globular portion;

a closed loop core structure consisting of ferrite having a central opening, lying partially within and partially without said envelope;

means for energizing said core with a radio frequency magnetic field;

an ionizable medium within said envelope adapted to sustain an electric discharge due to an electric field induced therein by said ferrite core and to emit radiation at a first wavelength when sustaining said discharge; and

a luminescent phosphor disposed on the interior of said envelope and on the surfaces of said ferrite core structure lying within said envelope, said phosphor being adapted to emit visible light when excited by said first wavelength radiation.

2. A lamp as claimed in Claim 1, wherein the said core has a loss factor of less than 50 per cent.

3. A lamp as claimed in Claim 2, wherein the said core has a loss factor of less than 2·5 per cent.

4. A lamp as claimed in any one of the preceding claims, wherein the said ferrite has a relative magnetic permeability greater than substantially 2000.

5. A lamp as claimed in any one of the preceding claims, further comprising a layer of gas impermeable, glass material disposed on said core structure and adapted for receipt of said phosphor, whereby gases contained in said core structure are maintained separate from said ionizable medium and the adhesion of said phosphor to said core structure is facilitated.

6. A lamp as claimed in any one of the preceding claims, wherein:

said envelope further comprises a flat base part containing a substantially rectangular perforation through which said core structure sealably penetrates said envelope, and

said core structure has a substantially rectangular cross-section.

7. A lamp as claimed in Claim 6 further comprising a rectangular bridge sealed to said core structure and to said envelope and covering said rectangular perforation within said central space of said core structure.

8. A lamp as claimed in any one of Claims 1 to 7 wherein said means for energizing said core structure comprises:

a winding provided on the portion of said core structure lying without said envelope with a plurality of turns and

a radio frequency power supply connected to said winding and adapted to receive input energy at line voltage and frequency and to convert said input energy to a radio frequency electric current in said winding, whereby said radio frequency magnetic field is induced in said core structure.

9. A lamp as claimed in Claim 8 further comprising:

a hollow, cylindrical base member, having a first end attached to said envelope, enclosing said portions of said core structure lying without said envelope and further enclosing said radio frequency power supply; and

means for receiving said input energy, attached to an end of said base member opposite said envelope.

10. A lamp as claimed in Claim 9 wherein said means for receiving said input energy comprises a lamp base plug.

11. A lamp as claimed in any one of Claims 1 to 10 wherein said core structure comprises:

an annular ferrite core whose losses are less than 50 per cent whose permeability is greater than substantially 2000 at frequencies between substantially 25 kHz and substantially 1 MHz;

an annular metal container enclosing said ferrite core, said metal container having an opening extending about its inner major circumference; and

a dielectric material filling said perforation whereby electrical conduction about the minor circumference of said container is prevented.

12. A lamp as claimed in Claim 11 wherein said metal container is evacuable.

13. A fluorescent lamp comprising:

a light-transmissive envelope having a substantially globular portion, a flat base part, and a re-entrant tubular projection containing two oppositely-positioned rectangular perforations and extending from said base part;

a closed loop core structure consisting of ferrite having a central opening, sealably penetrating said envelope through said rectangular perforations;

means for energizing said core structure with a radio frequency magnetic field;

an ionizable medium, contained within said envelope, adapted to sustain an elec-

tric discharge due to an electric field induced therein by said ferrite core structure and to emit radiation at a first wavelength when sustaining said discharge; and

a luminescent phosphor disposed on the interior of said envelope and on the surfaces of said ferrite core structure lying within said envelope, said phosphor being adapted to emit visible light when excited by said first wavelength radiation.

14. A lamp as claimed in Claim 13 wherein said rectangular openings lie adjacent to the inwardly directed end of said tubular projection and the inwardly directed end of said tubulation and said ferrite core structure are sealed to a flat disk.

15. A lamp as claimed in Claim 13 or Claim 14 wherein said means for energizing said core structure comprises a winding provided on said core with a plurality of turns and lying within said tubulation and means for energizing said winding with a radio frequency electric current, said current having a frequency between substantially 25 kHz and substantially 1 MHz.

16. A lamp as claimed in Claim 15 wherein the means for energizing said winding comprise:

a cylindrical base assembly having one end attached to said base part of said envelope;

a radio frequency power supply contained in said base assembly and adapted to receive input energy at line voltage and frequency and to convert said input energy to said radio frequency electric current in said winding; and

a lamp base plug attached to said base assembly at an end opposite said envelope and adapted to receive said input energy from existing lamp sockets and to supply said input energy to said radio frequency power supply.

17. A lamp as claimed in any one of Claims 13 to 16 wherein said ferrite core structure comprises:

an annular ferrite core whose relative permeability is greater than substantially 2000 and whose losses are less than 50 per cent at frequencies between substantially 25 kHz and substantially 1 MHz;

a flat metal strap surrounding the outer major circumference of said ferrite core; and

a layer of gas-impermeable, glassy material disposed on said ferrite core and said flat metal strap.

18. A lamp as claimed in Claim 17 wherein said flat metal strap comprises materials selected from the group consisting of copper and aluminium.

19. A lamp as claimed in Claim 17 or Claim 18 further comprising heat-dissipating means bonded to said flat metal strap within said tubular projection of said envelope.

20. A lamp as claimed in Claim 19 wherein said ionizable medium comprises a mixture of rare gas and mercury vapour.

21. A lamp as claimed in Claim 20 wherein the rare gas is krypton.

22. A lamp as claimed in Claim 20 or Claim 21 wherein said ionizable medium has a pressure between 0·2 torr and 2·0 torr.

23. A lamp as claimed in Claim 1 substantially as hereinbefore described with reference and as illustrated in Figures 2 to 8 of the accompanying drawings.

24. A lamp as claimed in Claim 13 substantially as hereinbefore described with reference to and as illustrated in Figures 2 to 8 of the accompanying drawings.

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1555096 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

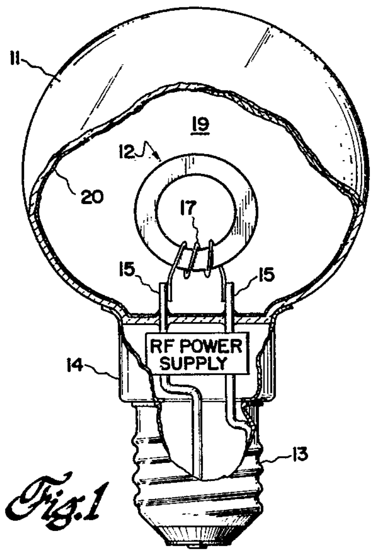


Fig.1

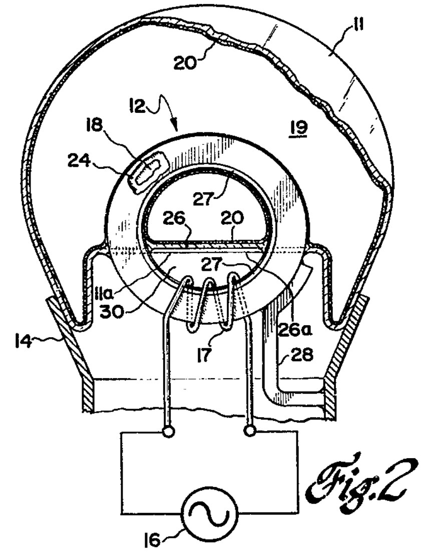


Fig.2

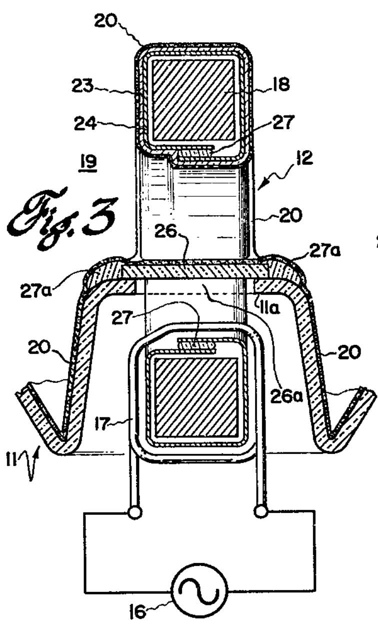


Fig.3

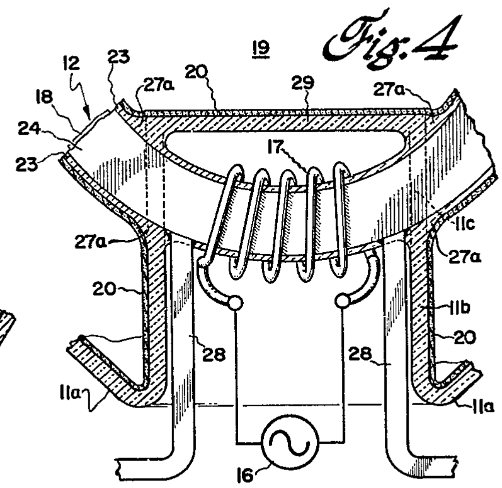


Fig.4

Fig. 5

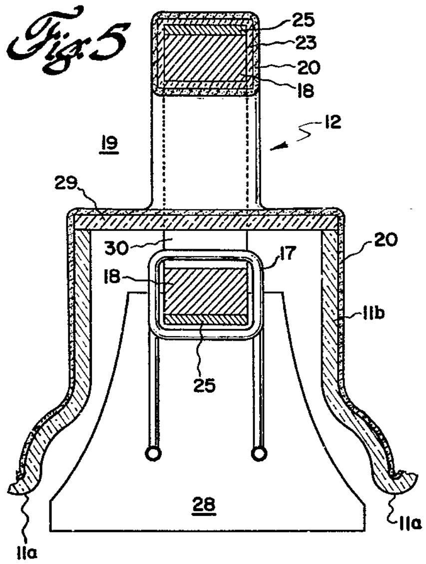
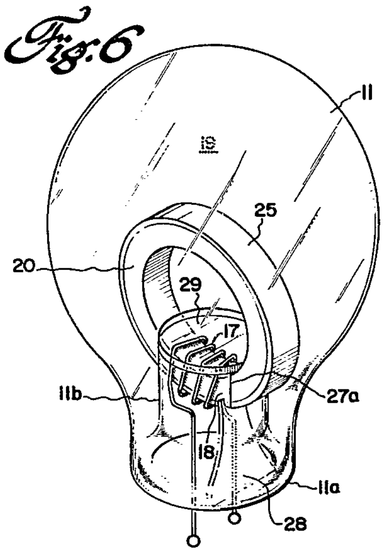


Fig. 6



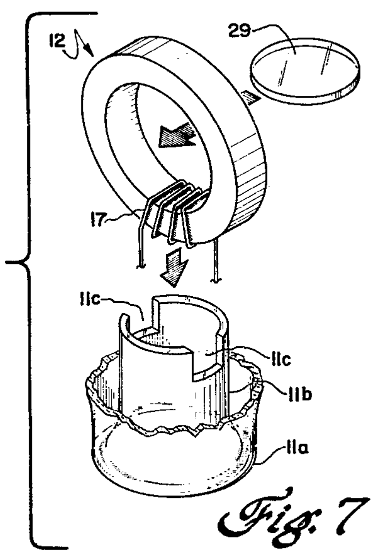


Fig. 7

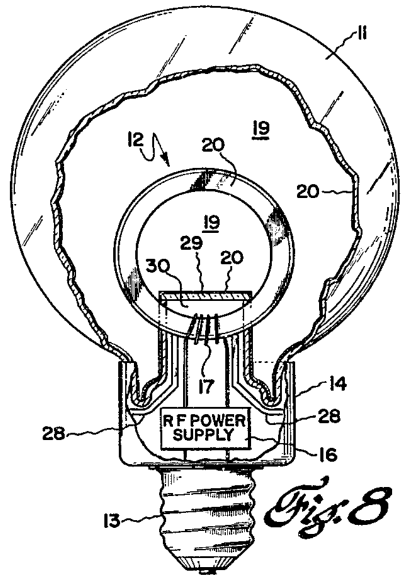


Fig. 8